"The greatest mission this Agency has ever accepted is helping to open the mind of a child to unimagined possibilities." - NASA Administrator Sean O'Keefe	*"When it comes to the education of our children . . . failure is not an option."* - President George W. Bush

Learning Technologies

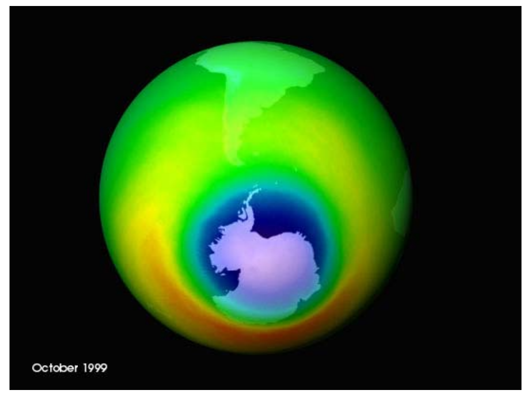
"We accelerate learning to the speed of enlightenment"

NASA Vision	**NASA Mission**
To improve life here, To extend life to there, To find life beyond	To understand and protect our home planet To explore the Universe and search for life To inspire the next generation of explorers …as only NASA can

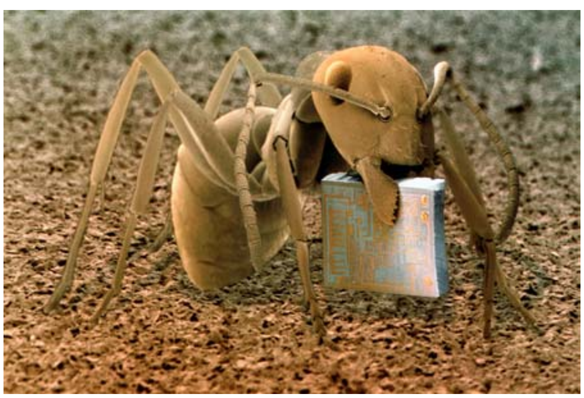
"Today, America has a serious shortage of young people entering the fields of mathematics and science.
A critical part of NASA's Mission is
to inspire the next generation of explorers
so that our work can go on.
This educational mandate is an imperative."

—NASA Administrator Sean O'Keefe

NASA *Learning Technologies* is all about NASA, in its legendary role of pushing the limits of what's possible. NASA Learning Technologies develops technology that allows '*NASA*' science and engineering to be delivered to students in the most dramatic manner possible.



Interact with the Earth in spectacular 3D. Access and manage terabytes worth of satellite data. ***Play scientist or engineer*** with years' worth of daily global data for temperature, precipitation, cloud cover, snow cover, leaf cover, ozone concentration, etc. Create time sequences for what you want to see. Save the images or movie for your report.



Ant and microchip courtesy of Andrew Syred/Science Photo Library

See your world enlarged over 500,000 times with a scanning electron microscope. View specimens from arthropods to microchips, exactly the way NASA scientists do, with a computer.

These learning technology tools are available to the classroom, the home, science centers and tech museums. These tools provide an experience that is visually rich and highly interactive, often immersing you into 3D worlds that deliver science in a uniquely engaging way.

This NASA-developed software is modular (componentry), meaning that it can be freely leveraged by the educational community in any software application.

NASA Learning Technologies' (LT) goal is to share the excitement of science and engineering in the most engaging, sustainable, and accessible manner possible. Video game technology has made rich visualization of virtual reality possible on today's $800 PC. The internet, CDs and DVDs have made possible delivery of data in ways previously unimagined. LT makes possible the access to NASA science and engineering by leveraging these entrenched technologies of video performance and data access to inspire and motivate the learner.

LT increases the accessibility to math and science for both blind and sighted students with cutting-edge ADA (Americans with Disabilities Act) assistance tools. LT then applies these tools to prototype learning experiences so that the educational community can further leverage them in ways yet unimagined.

Table of Contents

1 NASA Education Enterprise

The NASA Education Enterprise has developed a strategy to inspire and motivate students at all levels to pursue careers in the fields of science, technology, engineering, and mathematics.

NASA Learning Technologies implements the transformations identified in the NASA 2003 Strategic Plan, specifically "Education programs will utilize technology to improve student learning and increase access to NASA research and development."

2 NASA's Goal 6

Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics (STEM)

2.1 NASA Strategic Objective 6.4

"Increase student, teacher, and public access to NASA education resources via the establishment of e-Education as a principal learning support system."

"NASA [Learning Technologies] *works to develop new methods of making exciting* [NASA] *discoveries and valuable* [NASA] *resources available to students, educators, and researchers… NASA is committed to finding the right balance in this challenge so that education customers continue to have access to NASA's engaging science content through digital media."* (NASA Education Enterprise Strategy, page 26)

2.2 NASA Outcome 6.4.1: Education Technology R&D

"By 2008, identify and implement four new advanced technology applications that will positively impact learning."

2.3 FY04 Annual Performance Goal (APG) Milestones

6.4.1 APG: "Benchmark advanced technology tools/applications under development to determine the 4-6 with the most impact potential for NASA e-learning."

Internal Benchmarking: Quality Assurance/Quality Control

The technologies described below, except for WorldWind, were selected from a large collection of proposals submitted by NASA employees to the NASA Learning Technologies Office in fiscal year 2002. Ten of the proposals were competitively selected for a one-year opportunity to develop a prototype and received performance-based funding for one year (FY03). After one year, four of the ten prototypes were selected by means of a second competitive and rigorous selection process. The selection criteria, based on the NASA SBIR review criteria, required not only that the technology be compelling but that it be evaluated by teachers, students, and independent scientists and engineers within NASA.

In order to ensure educational value, educational appropriateness, and alignment with national standards of the project deliverables, the projects work closely with one or more experienced educational technology experts familiar with the research and state of the art in the project's educational technology domain. These experts guide and assist the project team in its choices of educational material, delivery metaphors and user interface, and with technology evaluation of the project deliverables and the technology those deliverables incorporate.

Additionally, the project manager or members of the project team designated by the project manager complete the Virtual Design Center online training in research-based educational technology design provided by NASA Classroom of the Future. (See http://www.cotf.edu/vdc for a description of the training.)

The ongoing development of these learning technologies, will continue to be evaluated by these groups to affirm or correct the technology directions and to determine the most practical and effective ways to use the technology.

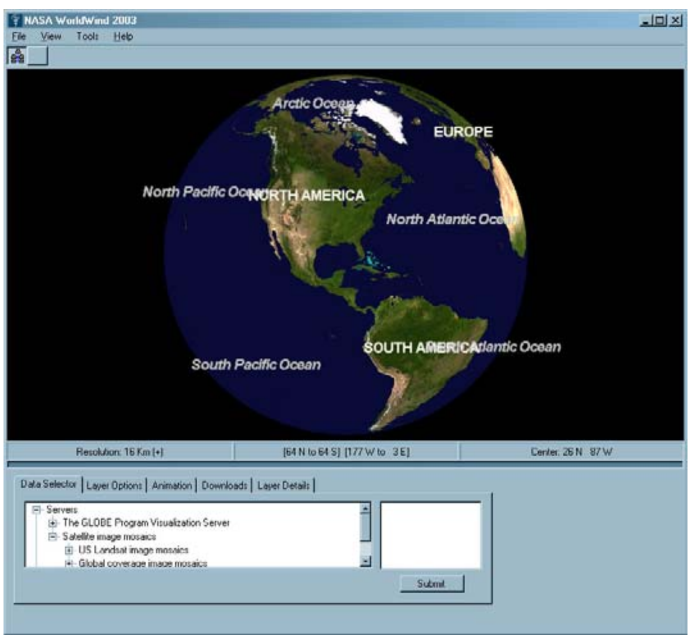
2.3.1 Milestone 1: External Benchmarking Study of *Advanced Technology Applications*

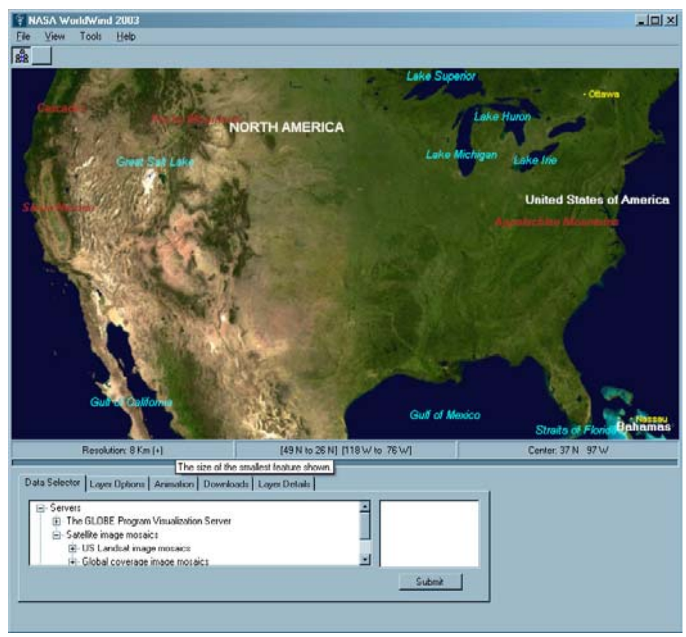
The Project Office will update the previous NASA Learning Technologies Benchmarking Report (December 2001). This deliverable will be based on a benchmarking study completed by 10/1/2004. This study will assess the current state, activity, and emphasis of educational technology in industry and academia, will survey industry leaders in innovative technologies currently under research, and will make recommendations based on findings.

2.3.2 Milestone 2: WorldWind, *Advanced Technology Application*

- Develop and deliver a sophisticated planetary visualization tool utilizing NASA data and based on the NASA Open Source Agreement software license.

The phenomenal increases in performance and decreases in price of computer technology has made what was once "high-end" capability now available to everyone with a simple desktop computer costing less than $800. Many software applications we could only see in museums, universities and large enterprises are now available to students both at school and at home.

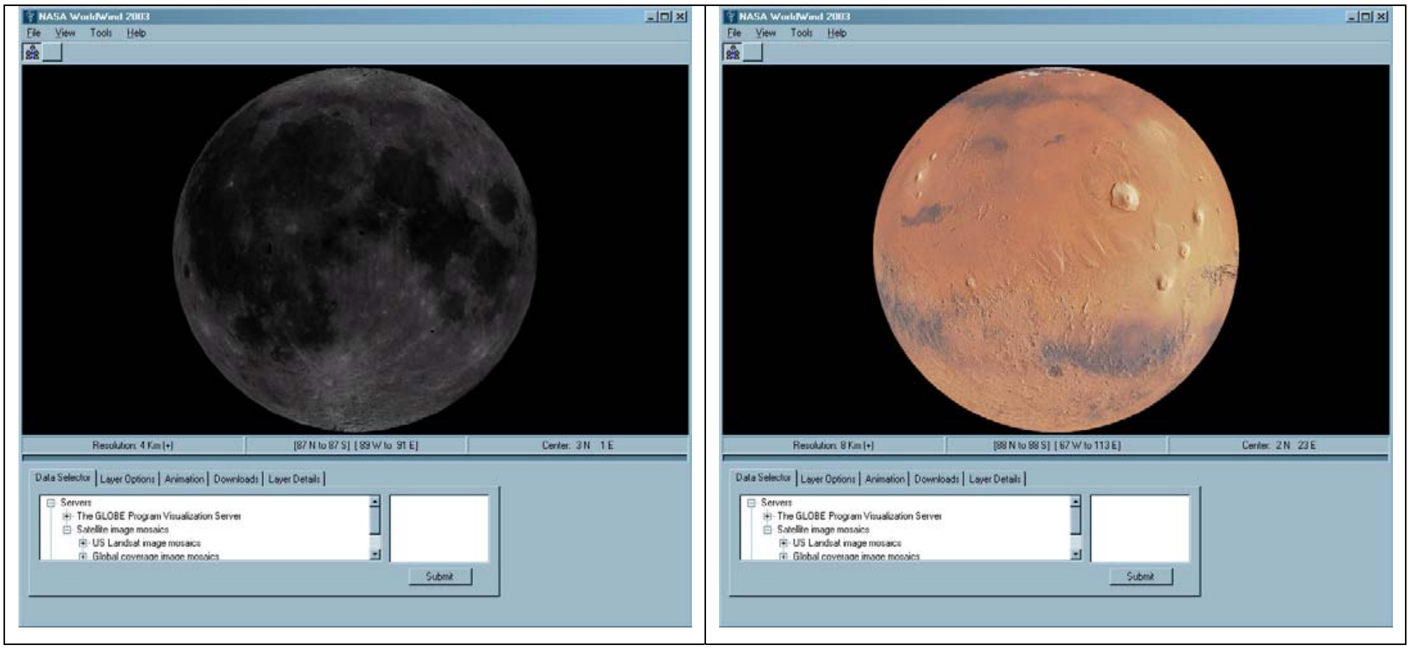




Imagine having access to a 3D Earth textured with real photography taken by NASA astronauts and satellites. The detail becomes more precise as you zoom in, with place-names of physical and political features fading in and out depending on your proximity to the surface. You now have in your hands a virtual globe far richer in detail than anything found rotating on a desk.

Until recently, this capability was available only on very expensive and highly specialized computers. This sophisticated software uses spatial subdivision of imagery and annotation to enable interactive performance on commodity computers.

This software will be utilized by educators and students to teach and study planetary geography, surface science, and environmental science of planets and their moons, and as a highly accessible reference tool for large data sets associated with that same information. It is expected to allow interaction and information delivery well beyond that provided by a physical globe, including the ability for users to add their own information and annotation. The software can also serve as a globe for any celestial body for which there is quality imagery and related feature information.

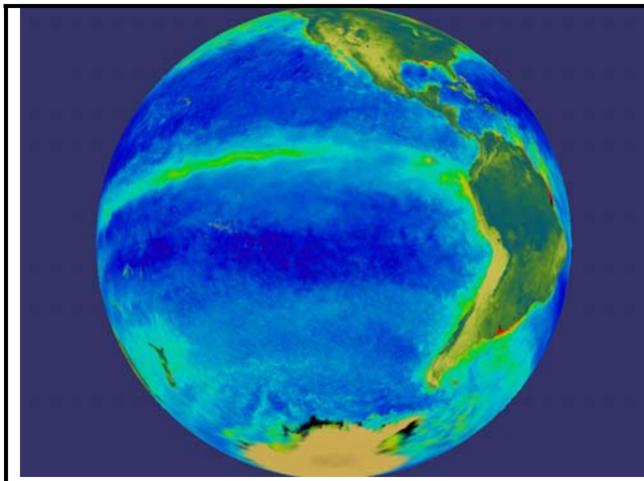


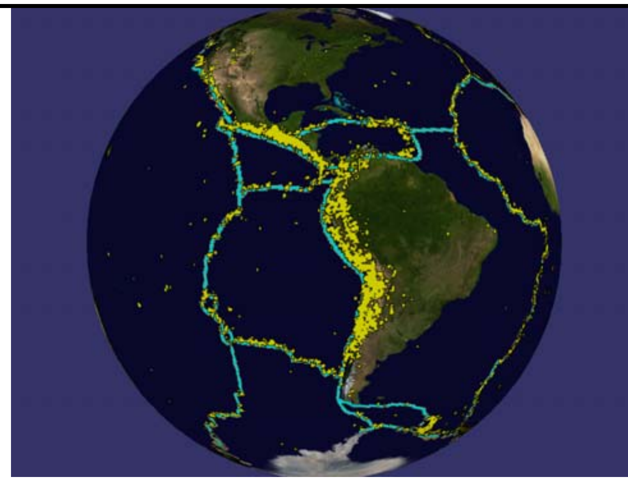
The software will also be utilized by software developers as a component that their application can incorporate thereby creating new educational or commercial applications that can benefit from the interactive 3D display of planet imagery, satellite data, and related feature information. This kind of technology and its ability to be easily incorporated as componentry is not currently available to application developers.

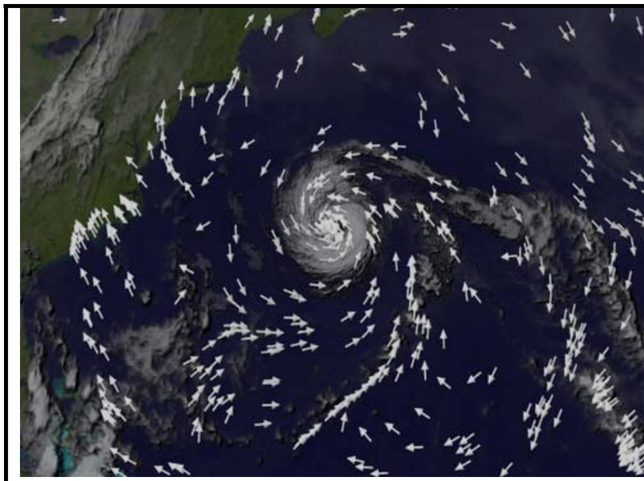
2.3.3 Milestone 3: Animated Earth, *Advanced Technology Application*

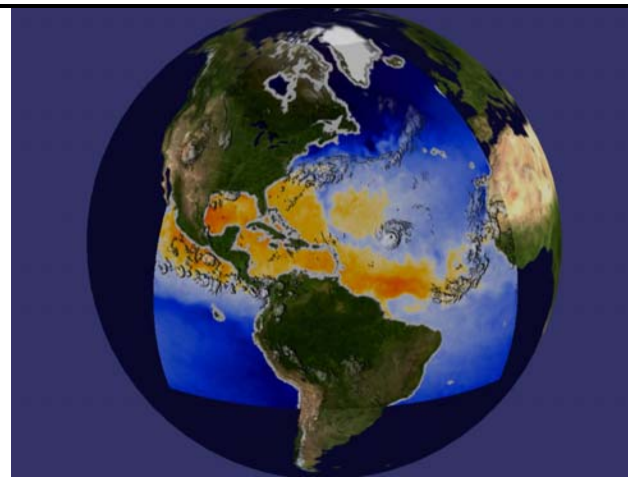
- Provide internet-accessible animated visualizations of important Earth Science processes, events, and phenomena to students, educators and the public, using NASA remote sensing and model data.
- Determine which standards and protocols will be adopted to convey these visualizations over the internet
- Implement and document a public server-side infrastructure to deliver these visualizations using the chosen standards and protocols.

Animated Earth provides models of the Earth in full 3D, allowing students to interact with it the same way they would a video game. The Animated Earth globe displays more than static information. A second aspect is the display of physical-phenomena animations that overlay the 3D model and can be “played” forward and backward in time. Students can thus interactively study hurricanes, temperature distributions and changes, land usage or population changes, animal migrations, wind patterns, ocean currents, or any of a huge number of phenomena for which there is available data, all in the context of an accurate and visually engaging Earth model. The Animated Earth project team is creating many animations, all of which will be freely available over the internet and seamlessly displayed at the student's computer.


Phytoplankton Concentration


Earthquakes Distribution


Hurricane Wind Patterns

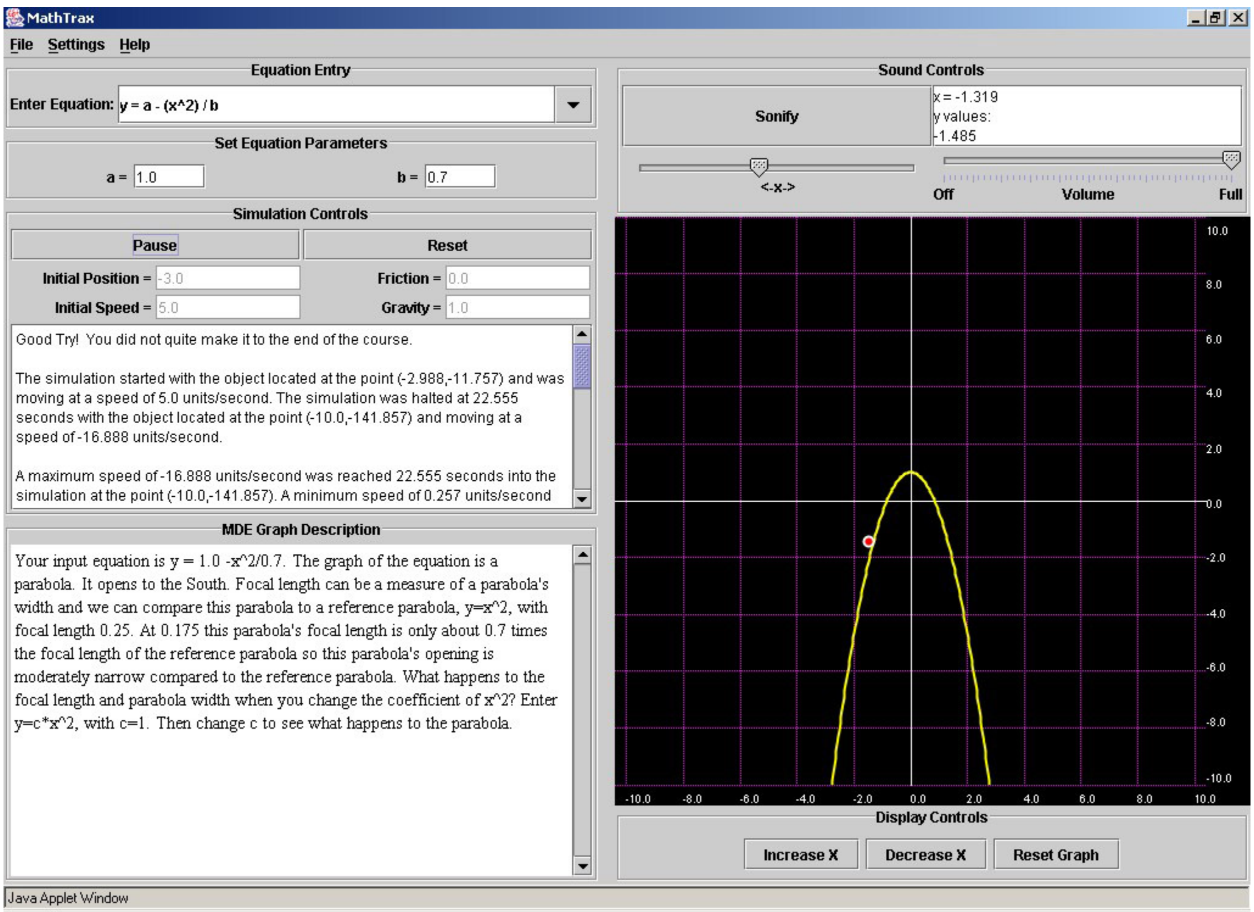

Hurricane Tracks

Additionally, the Animated Earth team is creating an open standard and open-source server software to provide a means for organizations other than NASA to publish, serve and receive animated earth-science information. Ideally, developers of new and existing earth-science applications will design them to utilize this new standard and thus establish broad support for the creation and use of this type of animated information. The project is also using several existing standards such as the Web Mapping Service [1] and XML [2].

2.3.4 Milestone 4: Math Description Engine, *Advanced Technology Application*

- Provide software tools that enable development of assistive instructional software applications for sensorily impaired K-12 students.
- Utilize a combination of graphing, sonification, and mathematical analysis software to represent mathematical and scientific information.
- Provide unique, NASA-technology teaching tools that enhance STEM education for sensorily impaired students.

Imagine being able to *hear* mathematics. Type in a function, hear how it sounds — in stereo — as the independent variable moves forward in its domain, all the while seeing the function graphed on the computer screen. This is the first goal of NASA's Information Accessibility project, and it's been realized in software technology we call the Math Description Engine.



Although originally envisioned as an aid for sight impaired students, Math Description Engine proved to make math more accessible to both blind *and* sighted students. Each receives an additional sensory input about the graph of a function they're studying. Math Description Engine provides sonic feedback on virtually any two-dimensional function in rectangular or polar coordinates. Students either type in an equation or select one from a list. The equation is then graphed on the screen, and tones are played that vary in pitch and intensity to sonicly describe the shape of the curve and the relative locations of its points. For example, a simple linear curve with positive slope would generate a tone of increasing pitch from left to right.

Sight impaired students using a computer invariably use "screen reader" software to help them navigate the screen and control the computer. Screen reader software reads aloud text on the screen, and gives audio guidance and feedback for interactions such as keystrokes and menu selections. It enables a blind person to efficiently use a graphical user interface. Math Description Engine participates in this by providing textual descriptions of functions as well as sonic descriptions. The screen reader software reads the textual description out loud to the student. These textual descriptions are not precomposed; they are generated on-the-fly by software that analyzes the function and determines its characteristics. Indeed, this is one of the major innovations of the software. Similarly, the sonifications and graphs of the functions are not precomposed. This run-time analysis allows Math Description Engine to evaluate most functions of two variables.

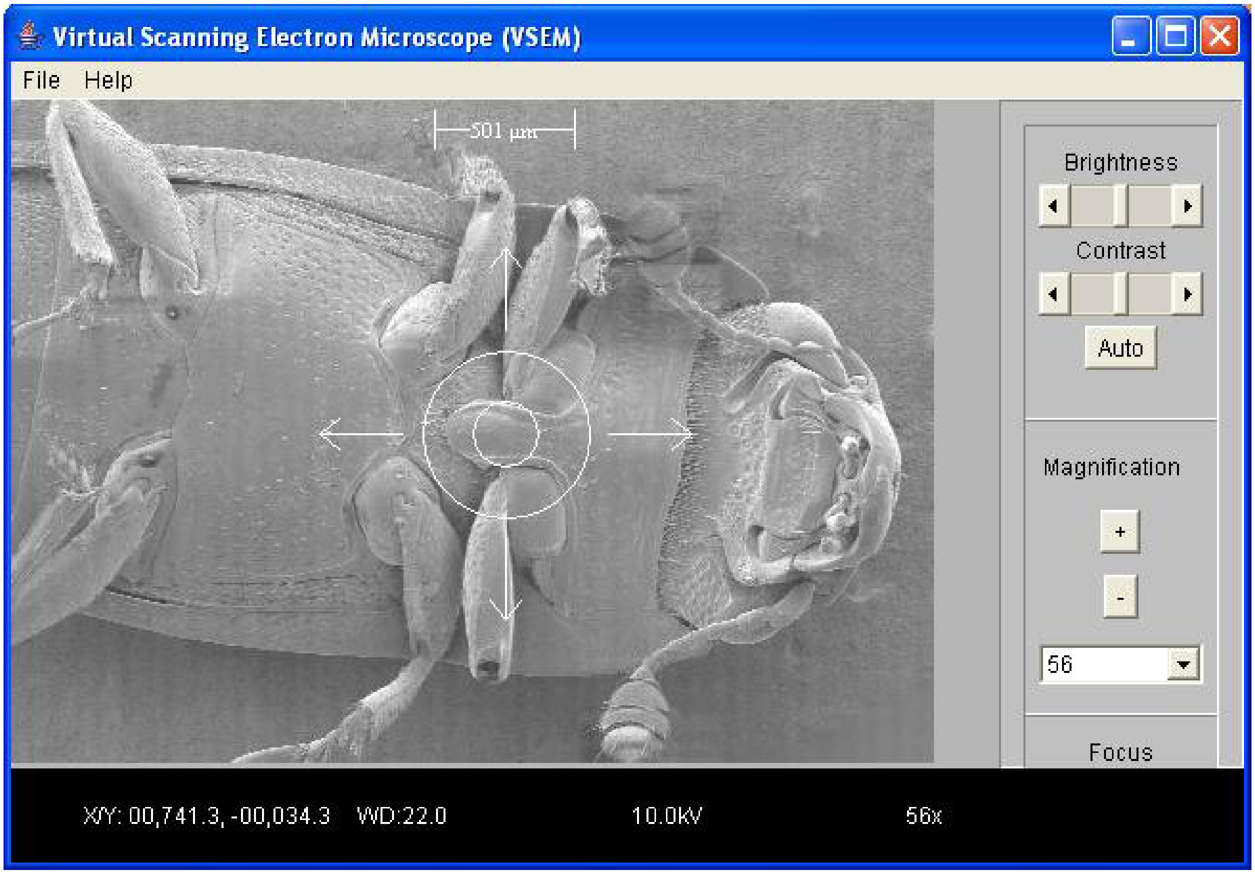
The Math Description Engine is only the first product of the Information Accessibility project. The project team is now developing software to sonicly describe three-dimensional information such as temperature and pressure fields. Imagine yourself moving through the atmosphere and hearing the subtle changes in wind, temperature and moisture. Imagine an astronaut — or yourself as an astronaut — hearing the radiation streaming from the sun during a space walk. By adding an audible dimension to these phenomena, we hope to enable students to achieve a better understanding of natural phenomena.

2.3.5 Milestone 5: Virtual Lab, *Advanced Technology Application*

- Provide students and their educators with virtual but realistic software implementations of sophisticated scientific instruments commonly used by NASA scientists and engineers.
- Design and implement the virtual instruments such that additional specimens can be added easily and additional instruments can be used to study the same specimens.
- Build on the LTP Phase 1 Virtual Lab by expanding the set of specimens for the Virtual Scanning Electron Microscope.
- Provide mechanisms to enable independent applications to invoke and contain the virtual instruments

NASA scientists and engineers use many sophisticated instruments in their work. Scanning electron microscopes, mass spectrometers, and X-ray microscopes are examples of devices employed continually within NASA to assist technologists performing design, investigation and analysis. In fact, these instruments are used widely throughout science and engineering, and mastery of their use is necessary for many practicing researchers and designers. Because these instruments are very expensive, students have limited access to them. And since the instruments are fragile and in some cases dangerous, student use must be monitored closely.

The Virtual Lab hopes to alleviate this situation by providing *virtual* instruments: software implementations that have the same feel and feedback of the actual instruments, and can be used in training. Students can use these to gain familiarity, practice procedures and protocols, and even explore precomposed specimens that illustrate the investigative details they'll encounter or search for in real investigations.



A virtual instrument example is shown in the figure above. Here is displayed Virtual Lab's scanning electron microscope. A beetle specimen is "under the gun." The user interface is very similar to that of a real scanning electron microscope: it contains contrast, brightness and focus controls, a measuring instrument (the movable ruler currently at the upper right of the window), and magnification controls. Movement of the electron beam is controlled by the mouse and keyboard, just as it would be with a real electron microscope.

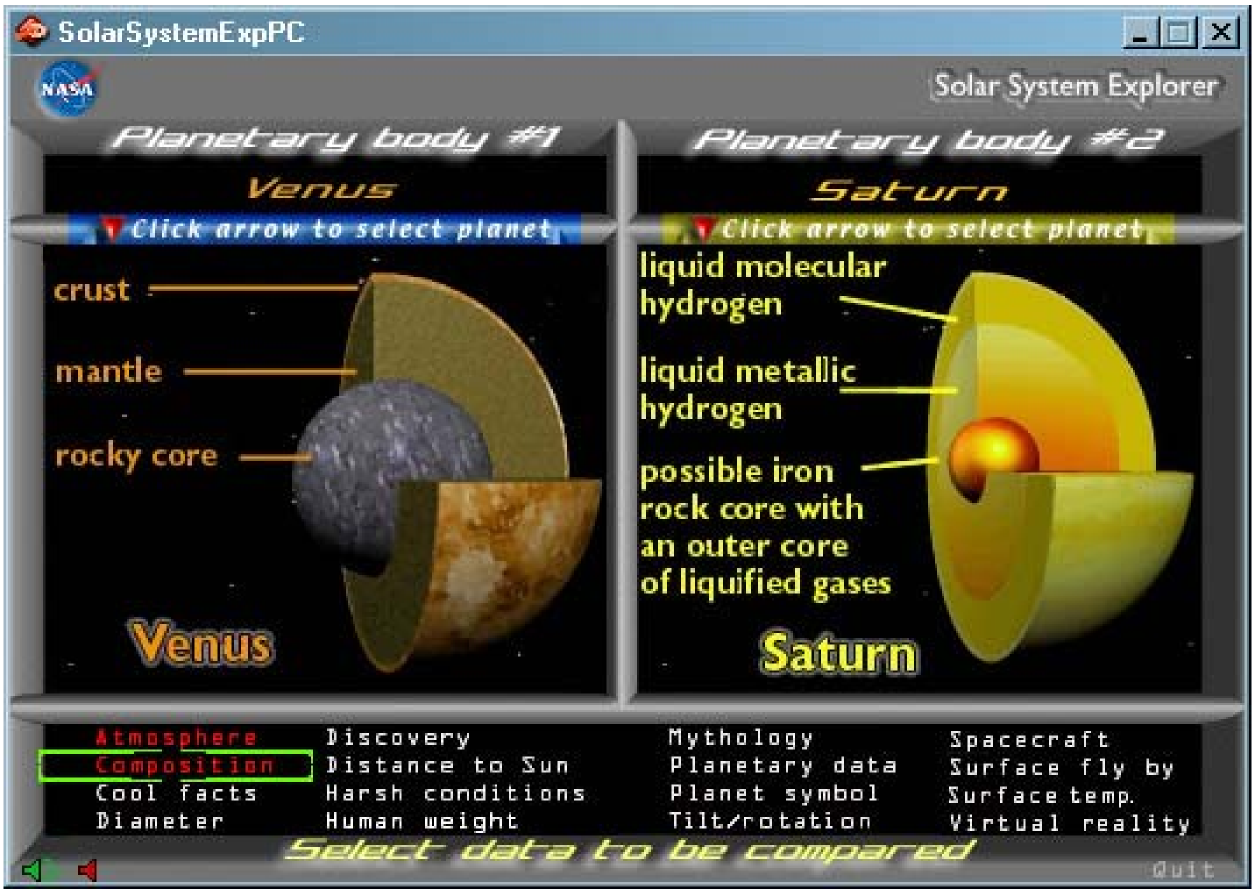
The specimen displayed in the figure — the beetle — is of course virtual as well. Within the software it consists of thousands of individual images taken at different magnifications and using different focal points. The software automatically and seamlessly displays the correct images for the current beam position, focal point and magnification. These parameters are all under control of the virtual-instrument user, and the feedback is immediate.

The original images were generated by automated software driving a real scanning electron microscope. This makes it very easy to continually generate additional images of interesting specimens.

The virtual specimens and the virtual instruments are described in XML [2]. The XML schemas for them are publicly available, thereby enabling other organizations to develop additional instruments and additional specimens that interoperate with existing ones. The goal of Virtual Lab is to develop up to five virtual instruments by project completion in FY 2005, and at least 20 specimens for each instrument. Ideally, the specimens will be coordinated among the instruments so that an array of the instruments can be employed to study a common specimen in different ways.

2.3.6 Milestone 6: What's The Difference?, *Advanced Technology Application*

- Provide a simple to use software component that uses richly visual and highly interactive comparisons to teach science and math concepts.
- Design the component so that additional information and new information sets can be developed and easily added by curriculum developers.
- Enable developers of educational software applications to utilize the visual comparison componentry and information in their applications.
- Provide information sets and tool capabilities beyond those delivered for this project's phase 1 effort.



Comparison can be an effective teaching technique. *What's The Difference?* is a software application that displays similar information, side-by-side, about different things.

The composition of planets, for example, is more interesting and understandable when shown in comparison, than it would be shown in isolation. In the figure above, the planetary composition of Venus and Saturn are shown together, giving a clear comparison between the two and providing the student with a mechanism to understand the information in context and to help her remember it.

What's The Difference? can provide this comparative presentation for any type of information, not just planetary data. Information from Chemistry, Physics, and Biology have been suggested by educators who have used What's The Difference?. You can imagine, for instance, comparing various aspects of molecules such as their molecular structures, weights, uses, and the polymers they form. For such a topic as "Molecules" the lower selection window would display the comparative aspects, while the drop-down menu under the triangle would allow selection of different types of molecules. Of course, the window annotation would change as well, to language appropriate to the topic, perhaps "Molecule" and "Molecular Explorer" in our example.

The infrastructure and data definition standards for *What's The Difference?* will be clearly documented to allow curriculum designers to prepare topic material. In addition to graphics similar to those in the figure above, video, sound, Flash™ and interactive programs can be configured to display in *What's The Difference?* windows. Many commonly used industry standard formats are accepted so that curriculum developers may use industry standard tools to create content. The *What's The Difference?* project team is currently extending the application to allow for more data windows and other useful capabilities.

3 NASA Learning Technologies Operating Principles

3.1 Customer Focus

LT does research development in the area of interactive teaching tools that are enriched with NASA content. These NASA-content delivery vehicles provide prototype learning experiences that the educational community can readily leverage with additional learning experiences. Input and feedback from, and collaboration with NASA scientist and engineers, classroom teachers and students, enhance the product development and assure effective content. All products will be freely available to the educational community via website delivery or CDs/DVDs.

3.2 Content

All learning tool prototypes are specifically based on delivery of NASA content, including live data feeds of satellite imagery, e.g., global temperature, precipitation, cloud cover, LandSat, etc.. The data presented has been received or gleaned from the respective NASA technical professional for that data or has been reviewed by appropriately qualified NASA personnel, is exemplary of NASA-specific data or activities, and supports the national STEM agenda by providing engaging and interactive learning tools that can readily go into the classrooms and homes with little or no teacher or parent orientation required.

3.3 Pipeline

Prototype guided activities embedded in the learning tool engage the learner in an inquiry-based manner that challenges their skill development in the areas of math and science. Progression through the learning experience is user-controlled, allowing those with different learning styles to progress at their own rate. These prototype learning products will be freely available and graphically rich, making them accessible and desirable to the widest possible audience. LT will identify specific targeted populations for marketing prototypes (educators) and seek creative avenues for reaching diverse student populations. Wide distribution is made more plausible when combined with the ability to run LT products on today's commodity PCs. The learning experience will be user controlled and highly configurable to better address respective learning styles.

3.4 Diversity

The learner will be able to control their rate of progress through the guided activity. One LT product is developing the technology to make the learning experience available to the blind. This tool will be leveraged by multiple Projects. Additionally, 508 compliance will be achieved whenever possible and applicable. The products prototype engaging math and science activities. The freely available and graphically rich nature of these learning technologies, make them accessible and desirable to the widest possible audience. This wide distribution is made more plausible when combined with their ability to run on commodity PCs.

3.5 Evaluation

Individual Projects making up the program have an internal quarterly review. Continued funding is based on performance measured against two criteria guiding documents, the Learning Technologies Universal Requirements (peer reviewed) and the specific Project Data Sheet generated by the Project Office in concert with each Project. Annual review of the Projects by a panel composed of relevant independent personnel from both inside and outside the Agency. Their input is directly related to the generation of the Learning Technologies Universal Requirements document. The annual review for each Project is based on the NASA established NASA Small Business and Innovative Research (SBIR) program review criteria and criteria established in the Learning Technologies Universal Requirements and the respective Project's Project Data Sheet. The NASA educational partner Classroom of the Future (COTF) Virtual Design Center provides annual support for the product development of each Project.

3.6 Partnerships & Sustainability

Product development is based on open source standards whenever possible or minimal-cost licensing that will not inhibit use in schools and homes. Most of the teaching tools we develop are freely distributable and provide very attractive access to NASA content that can then be leveraged by the educational community, including commercial enterprises. These entities can then provide value-added products to these tools and then freely market them. The initial teaching tool will still remain freely available for further development and use by all, it is the add-on products which are then marketed by commercial entities. This means that any and all educational institutions will always be able to replicate and leverage these tools for their desired purpose.

Sustainability results from the nature of the products due to their open source nature, their ability to provide continuous dynamic access to NASA data, their ability to be further leveraged by both commercial enterprises and open source development, and their richly engaging graphical experience.

4 Project Data Sheets (following pages)

4.1 Animated Earth Project Data Sheet (PDS)

4.1.1 Project Objectives (one year)

- Provide internet-accessible animated visualizations of important Earth Science processes, events, and phenomena to students, educators and the public, using NASA remote sensing and model data.
- Determine which standards and protocols will be adopted to convey these visualizations over the internet.
- Implement and document a public server-side infrastructure to deliver these visualizations using the chosen standards and protocols.

4.1.2 Customers

- K-16 teachers, students, and the general public.
- Software developers desiring to include the visualization capability in their applications.
- Visualization providers other than the project team wishing to provide visualizations.

4.1.3 Use Cases

- An elementary school teacher displays on the classroom computer projector a collection of animated hurricane visualizations to illustrate the formation and behavior of powerful storms.
- A geography, history, or anthropology teacher displays animations of the change in population or land-use over time.
- Museums enable their visitors to interactively observe and discover patterns of current Earth events and phenomena.

4.1.4 Deliverables and Schedule

1. 15 Jan 2004 – Project requirements determined.
2. 30 Jan 2004 – Straw man list of visualizations to be created the first year produced.
3. 30 Jan 2004 – Adequacy of existing standards determined; definition of any required extensions to standards defined.
4. 20 Feb 2004 – Initial project partners identified.
5. Mar 2004 – Server-side infrastructure defined and requirements documented for clients and servers.
6. 15 Mar 2004 – Initial educator and curriculum developer review of first year visualization product list.
7. 30 Mar 2004 – First visualization available. Others at subsequent one-month intervals.
8. 31 Mar 2004 – Completion of Virtual Design Center Training.
9. 30 Jun 2004 – Initial (alpha) version of server-side software to deliver visualizations available and documented.

4.1.5 People

Project Manager: Horace Mitchell, Ph.D.,
NASA Goddard Space Flight Center,
301.286.4030,
Horace.Mitchell@nasa.gov

4.1.6 Partnerships

TBD

4.1.7 Dependencies

TBD

4.1.8 Assumptions

TBD

4.2 What's The Difference Project Data Sheet (PDS)

4.2.1 Project Objectives (two year)

- Provide a simple to use software component that uses richly visual and highly interactive comparisons to teach science and math concepts.
- Design the component so that additional information and new information sets can be developed and easily added by curriculum developers.
- Enable developers of educational software applications to utilize the visual comparison componentry and information in their applications.
- Provide information sets and tool capabilities beyond those delivered for this project's phase 1 effort.

4.2.2 Customers

- Curriculum and educational content developers.
- K-12 students and their teachers.
- Educational software application developers.

4.2.3 Use Cases

- Elementary school students use What's the Difference? independently or in groups to comparatively explore the features of planets, the domains of the animal kingdom, prokaryotes and eukaryotes, and the scientific concept of equilibrium, among others.
- Curriculum developers create new, themed content for interactive discovery, coupled with other curriculum elements such as lessons, activities and games.
- Educational software developers incorporate What's the Difference? in their applications to illustrate key distinctions between items or concepts, and to allow the user to interactively discover or explore these differences.

4.2.4 Deliverables and Schedule (year one)

1. 31 Jan 2004 – Moon data incorporated into Solar System Explorer. SSE terminal release.
2. 31 Mar 2004 – WTD design complete.
3. 31 Mar 2004 – Completion of Virtual Design Center training.
4. 30 Apr 2004 – Completion of work with COTF and AETT to evaluate planned deliverables and identify additional functionality and data sets.
5. 30 July 2004 – WTD functionally complete, with α quality.
6. 30 Sep 2004 – Report on initial content developer feedback.

4.2.5 People

Project Manager: Christina O'Guinn,
NASA Ames Research Center,
650.604.2891,
Christina.M.Oguinn@nasa.gov

Alternate Contact: Geoffrey Bruce,
NASA Ames Research Center,
650.604.2587,
gbruce@mail.arc.nasa.gov

4.2.6 Partnerships

Classroom of the Future (COTF)
NASA Explorer Schools
NASA Higher Education Collaborative
NASA Ames Educational Technology Team

4.2.7 Dependencies

Formation of the above partnerships.

4.2.8 Assumptions

Stable requirements and funding.
WTD application features include variable number of comparison windows, increased screen size, log, tutorial, and ability for content developers to easily incorporate new data sets and glossary.

4.3 Virtual Lab Project Data Sheet (PDS)

4.3.1 Project Objectives (two year)

- Provide students and their educators with virtual but realistic software implementations of sophisticated scientific instruments commonly used by NASA scientists and engineers.
- Design and implement the virtual instruments such that additional specimens can be added easily and additional instruments can be used to study the same specimens.
- Build on the LTP Phase 1 Virtual Lab by expanding the set of specimens for the Virtual Scanning Electron Microscope.
- Provide mechanisms to enable independent applications to invoke and contain the virtual instruments.

4.3.2 Customers

- High school, university and technical-college students who must become familiar with the instruments to achieve their educational or research goals.
- Junior high school science students learning the methods used to perform scientific investigation.
- Museums and science centers wishing to educate their visitors in the tools of scientific investigation and engineering analysis.

4.3.3 Use Cases

- Students studying to operate scientific instruments, either as a profession or as a skill necessary in their studies, use the Virtual Lab to gain familiarity with those instruments. Schools make the virtual instruments widely available at low cast for this purpose.
- Researchers employ the instruments to form or practice investigation protocols for their experiments.
- Science students in any grade use the virtual instruments to complete or augment their lab studies, reports or homework.
- Museum and science center curators incorporate the virtual instruments in automated or interactive displays to explain mechanisms, processes, methods or other aspects of scientific or engineering investigation and discovery.

4.3.4 Deliverables and Schedule

7. 15 Dec 2003 – Determination of number of instruments and specimens to develop.
8. 15 Jan 2003 – Selection of instruments.
9. 27 Feb 2004 – Initial educator review of plans.
10. 15 Mar 2004 – Selection of external instrument developers.
11. 31 Mar 2004 – Completion of Virtual Design Center training.
12. 31 Mar 2004 – First two additional SEM specimens available. Others to follow at one month intervals for six months.
13. 15 Jul 2004 – First prototype of second and third instruments available for student and teacher evaluation.

4.3.5 People

Project Manager: Berta Alfonso,
NASA Kennedy Space Center,
321.861.9083,
Berta.A.Alfonso@nasa.gov
Alternate Contact: Gregg Buckingham,
NASA Kennedy Space Center,
321.867.8777,
Gregg.A.Buckingham@nasa.gov

4.3.6 Partnerships

Beckman Institute at University of Illinois
KSC IT Simulation Group
Others to be established

4.3.7 Dependencies

IFMP and KSC/Glenn grant approval process.

4.4 Information Accessibility Lab Project Data Sheet (PDS)

4.4.1 Project Objectives (two year)

- Provide software tools that enable development of assistive instructional software applications for sensorily impaired K-12 students.
- Utilize a combination of graphing, sonification, and mathematical analysis software to represent mathematical and scientific information.
- Provide unique, NASA-technology teaching tools that enhance STEM education for sensorily impaired students.

4.4.2 Customers

- Vision impaired secondary students and their teachers.
- Sighted secondary students and their teachers.
- Researchers seeking information from complex, scientific data.
- Software application developers who wish to integrate IAL library components into their applications.

4.4.3 Use Cases

- Teachers use the IAL to instruct vision-impaired as well as sighted students in mathematics and science concepts.
- Researchers model mathematical equations and raw data using IAL as a means of visualization.
- Application developers incorporate IAL components to provide alternative representations of data, formulae and concepts.

4.4.4 Deliverables and Schedule (year one)

1. 5 Jan 2004 – Beta versions of Math Description Engine (MDE) Graphing Calculator and the MathTrax application available.
2. 31 Mar 2004 – Initial educator review of plans.
3. 31 Mar 2004 – Completion of Virtual Design Center training.
4. 30 Sep 2004 – One or more applications identified in which to integrate IAL components.
5. 30 Sep 2004 – Alpha versions of data description, sonification and graphing components ready for application integration. Each component is capable of independent instantiation, and is able to draw from sources including mathematical equations and data sets.

4.4.5 People

Project Manager: Robert Shelton, Ph.D.; 281.483.5901; robert.o.shelton@nasa.gov

Alternate Contact: Stephanie Smith; 512.291.1454; stephanie.l.smith1@jsc.nasa.gov

4.4.6 Partnerships

National Federation for the Blind (NFB) (http://www.nfb.org)

Southeast Regional Clearinghouse (SERCH) (http://serch.cofc.edu/serch) Special Needs Group

Texas School for the Blind and Vision Impaired (TSBVI) (http://www.tsbvi.edu)

4.4.7 Dependencies

None currently

4.4.8 Assumptions

A segment of the IAL user demographic will utilize a JAVA™ capable screen reader technology such as JAWS™ (http://www.freedomscientific.com) to relay aural information.

5 General Requirements for All Phase 2 Projects

All Phase 2 LT projects are subject to the following requirements.

5.1 Focus on Core Technology and Componentry

In order to ensure the widest utility of the project's technology, the projects shall focus their phase 2 efforts on developing componentry for use in educational applications. To ensure this, and to emphasize the technology's development as componentry, the project's core technology and software deliverables shall be integrated with at least two independently developed educational applications. One of these applications shall be selected by the LT Project Office; the other shall be recruited by the project's Project Manager. Arrangement for performance of the integration effort is the responsibility of the project team.

5.2 Collaboration with Educational Associates

In order to ensure educational value, educational appropriateness, and alignment with national standards of the project deliverables, the project shall recruit and work closely with one or more experienced educational technology experts familiar with the research and state of the art in the project's educational technology domain. These experts shall guide and assist the project team in its choices of educational material, delivery metaphors and user interface, and with technology evaluation of the project deliverables and the technology those deliverables incorporate. The LT Project Office can assist in recruitment of these experts. (See section 5.3 below.)

5.2.1 Classroom of the Future

Each project manager or members of the project team designated by the project manager shall complete the Virtual Design Center online training in research-based educational technology design provided by NASA Classroom of the Future. Classroom of the Future (COTF) Virtual Design Center (VDC) has coordinated with each of the four Projects to provide instructional technology expertise that will allow for the Project to better orient the development of their technologies toward more effective learning. Each Project Manager has a clear idea of the opportunity presented by the COTF VDC training and each appears well oriented to make the most of it. (See http://www.cotf.edu/vdc for a description of the training.)

The Virtual Design Center and the Learning Technologies program have teamed up to promote NASA early-stage advanced applications of technology. Virtual Design Center staff will conduct two sets of half-day workshops for the Association for Educational Communications and Technology (AECT) at its annual convention on October 19 and October 20, 2004. The first set of workshops will target conference attendees from instructional design and instructional technology communities. In conjunction with its annual conference, the Association for Educational Communications and Technology also conducts the International Student Media Festival. The second set of workshops supports STEM pipeline initiatives by targeting the International Student Media Festival's upper-level high school and undergraduate students. All workshop participants will interact with software prototypes and generate plans for incorporating the programs into designs for learning environments.

- The International Society of the Learning Sciences hosting The Sixth International Conference of the Learning Sciences, http://www.gseis.ucla.edu/~icls/, Wednesday morning, June 23rd, 2004; One 4-hour workshop. ICLS 2004 will be held in Santa Monica, California.

- Association for Educational Communications and Technology annual conference, http://www.aect.org/events/Chicago04/call/default.asp, with two 3-hour workshops scheduled on Tue/Wed, Oct 19/20, 2004 in Chicago, Illinois.

5.3 Collaboration with LT Project office

The LT Project Office will make available a technical and planning consultant (currently Tom Gaskins) to assist the project teams with software technology, project planning, and coordination with the Project Office. The office will also assist in locating and recruiting instructional technology consultants to help the project team discover and interpret education technology research that would guide them in their design and deliverable decisions (as described in section 5.2 above). The project manager shall keep these consultants continually apprised of significant decisions, of project status, and of any likelihood of deviations from the project's plans, deliverables or schedule.

5.4 Planning

Upon acceptance of these requirements, the project shall collaborate with the LT Office to compose an annual performance plan. This plan shall include a statement of goals and objectives, a comprehensive description of deliverables for the planning year, a schedule, and an evaluation plan to document outcomes and demonstrate progress toward achieving objectives.

The schedule shall include technology and deliverable milestones, as well as the recruitment, incorporation, and review of the educational technology experts. Upon mutual agreement between the project manager and the LT Project Office, this plan and schedule shall become a metric by which the project's performance is evaluated.

In addition, the project team shall clearly articulate how the plan contributes to the Education Enterprise annual performance goals that support NASA e-Education Objective (6.4) and Outcome 6.4.1 and Agency's strategic objectives and strategic outcomes for education.

Prior to final LT Project Office approval of annual project plans, those plans shall be approved by the Center Education Director of the project team's primary NASA center.

5.5 Portfolio Management

Under the auspices of the Education Enterprise's Technology & Products Office, the LT Project Office is implementing a portfolio management approach. This approach includes a rigorous evaluation of Phase 2 projects; periodic progress reports on performance metrics; annual performance evaluations using common criteria; and access to performance information for the entire portfolio. The portfolio management approach will provide information necessary for reallocation of resources; sunsets to projects, if necessary; and ensure a coordinated, non-duplicative set of Phase 2 projects that work together to achieve NASA's education goals.

The Education Enterprise has established operating principles. Every NASA-sponsored education program or activity is to be developed, implemented and evaluated according to these principles. LT Phase 2 projects shall build their technology tools in keeping with these ***Education Program Operating Principles***:

Customer focus	Designed to respond to a need identified by the education community, a customer, or a customer group.

Content	Makes direct use of NASA content, people, or facilities to involve educators, students and/or the public in NASA science, technology, engineering, and mathematics.
Pipeline	Make a demonstrable contribution to attracting diverse populations to careers in science, technology, engineering, and mathematics.
Diversity	Reaches identified targeted groups.
Evaluation	Implement an evaluation plan to document outcomes and demonstrate progress toward achieving objectives.
Partnership & Sustainability	Achieve high leverage and/or sustainability through intrinsic design or the involvement of appropriate local, regional, or national partners in their design, development, and dissemination.

5.5.1 Quarterly Review

The project shall undergo review each quarter of the project's duration. This review shall be conducted in-person with LT Office staff at the project's primary site. The reviews shall consist of a demonstration of the state of the project's technology and deliverables, an assessment of the project's status relative to its schedule, and an evaluation and possible adjustment of the project's direction and deliverables.

A quarterly report shall subsequently be submitted and made available from the LT Project Office internal web site for access by HQ Program Executive for Technology & Products Program Office and others, as identified.

5.5.2 Semi-Annual Review of Funding

Project funding shall be evaluated mid-year (prior to start of third quarter of the fiscal year) relative to the demonstrated performance of the project team and to the educational value of the project's technology. Projects not meeting their deliverables, schedule or other commitments, or whose technology has or is clearly becoming obsolete, or has insufficient alignment with NASA education goals and objectives may have their LT funding reduced or eliminated. (Such a proposed action will be forwarded by the LT Project Office to HQ and acted upon only upon concurrence and/or further direction by the NASA Education Enterprise Program Executive for Technology and Products.)

5.6 Annual Review by LT Review Panel

A thorough, in-person project review by the LT Review Panel shall be held in September 2004 at a location determined by the LT Project Office. This review shall include a full demonstration and evaluation of the project in its then-current state, and a description of its technology and then-current direction. This is to ensure that the project's technology remains relevant to NASA's education mission, and that there is independent concurrence that the project is performing to goals. Project teams should expect to reasonably adjust their goals and plans subject to feedback from this review.

5.7 Domain-Expert Validation

Prior to the project's first annual review, the project's technology and proposed deliverables shall be formally presented to one or more scientific or technological forums appropriate to the project's topic material. The feedback from these presentations shall be considered in the project's annual review.

5.8 Enterprise CIO and Education Officer Review

Project teams shall present their projects annually to the appropriate NASA Enterprise Chief Information Officers and Education Officers.

As described in section 5.4 above, annual project plans shall be approved by the Center Education Director of the project team's primary NASA center.

5.9 Lack of Encumbrance on Dissemination

The project deliverables shall not be encumbered by licensing restrictions unacceptable to the LT Project Office. They shall allow public dissemination of object code, data, imagery and electronic models without payment of royalties, other fees, or "share-back" requirements, including those imposed by use of independently developed free or purchased software, hardware, or data.

All source forms of code, data, electronic imagery and models created or caused to be created (i.e., "contracted" or "out-sourced") by the project shall be unencumbered for public dissemination.

5.10 Hardware and Software Target

The project's deliverables shall operate with end-user interactive performance acceptable to the LT Office on personal computers running Windows XP Home and on those computers running Mac OS-X, at the then-current service release of these operating systems. Minimal hardware of these computers is a single 1.5 GHz CPU, 512 MB of RAM, one 40 GB disk, one CD ROM, 1024 by 768 graphics resolution, and additional graphics or audio hardware each costing no more than $400 at the time of project commencement. These requirements are meant to ensure that the project's deliverables will operate acceptably on computer hardware and software purchased today and typically used by students and educators. Operation on Linux is not a requirement.

Run-time requirements shall include only commonly required software, such as an operating system, expected to be present on the user's computer. Accessibility software (e.g., JAWS) may also be required by the project software if the accessibility software is expected to be a normal part of the user's computer environment. Also permissible as run-time requirements are freely available and commonly used software such as a Java virtual machine, .Net run-time, Acrobat Reader, and major-brand media players. Exceptions to this may be made for minimal-cost software, but only with the approval of the LT Office.

The existence at run-time of a high-speed connection to the internet or a local network cannot be assumed, but the project deliverables may provide significantly more functionality in the presence of such connections. If a connection does not exist, the user must be able to utilize a significant subset of the functionality and content.

Deliverables targeted to PDAs shall assume a Pocket PC 2003 or Palm operating system and a device costing less than $500 in late 2003.

5.11 Integration Feasibility

The developed technology shall be easy to integrate into independently developed applications by independent software developers. Integration ability shall be programming-language independent, and support at a minimum project-technology clients using that client's choice of either Java, C# or C++ at the then-current versions and development platforms of those languages on Windows XP and Mac OS-X operating systems. XML shall be used to convey data, execution instructions and configuration information whenever appropriate. Existing appropriate and adequate standards shall be used when available.

5.12 Reliability

The project's software deliverables shall be thoroughly tested by the project team or its designee to ensure correct and trouble-free operation and behavior when interoperating with an application and an end-user.

5.13 Documentation

In support of item 5.11 above, the project shall provide professional quality documentation describing to software developers how to use the technology, and fully declaring and explaining the software or hardware interfaces. The documentation shall be accompanied by examples and, as appropriate to each project, a list of available data sources or other content repositories that the technology can operate with.

To the extent a deliverable provides direct, interactive access by a user, professional quality documentation and integrated electronic "Help" shall be provided with the deliverable.

5.14 Registration of Sharable Components and Content

To encourage re-use and discovery of the developed materials, the project shall register its software components, data and educational materials in appropriate public registries and databases. Suitable metadata describing the software shall accompany the registration. XML schemas defined by the project shall be registered with the NASA portal schema registry, and with other schema registries as appropriate.

5.15 Development Procedures and Mechanisms

The LT Office will establish procedures that projects shall use to protect, share and disseminate their deliverables. This will include source code control, defect tracking, electronic backup, and other commonly employed professional software development infrastructure. The Phase 2 projects shall actively participate in this infrastructure.

5.16 Best Practices for Software Development

The project deliverables shall be continually functional and available for operation on Windows XP PCs and Mac OS-X PCs. The LT Project Office is to possess operational, up-to-date source code, build and install instructions and installation software for all software deliverables. It is the responsibility of the project team to make reasonable efforts to ensure the LT Project Office is kept up-to-date.

5.17 Delivery

The LT Project Office is responsible for arranging intermediate and final dissemination of the project deliverables. The LT Project Office will establish guidelines and mechanisms that the project shall use to deliver materials to the LT Project Office.